Proposed Research and Development Plan

Ernest Malamud

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The overall R&D goal of the VLHC Study Group over the next 1-2 years is to evaluate feasibility and cost. Cost goals not only include lowering the capital cost for the collider, but also lowering the operating cost by efficient cryogenics, strong emphasis on reliability, and the use of automated installation, alignment, and repair methods wherever possible.

More specifically:

- The VLHC Study Group will produce a detailed design with cost estimates for 3 TeV (low-field) and 3 TeV (medium field) injectors so a choice can be made. This includes carrying out prototype work on all components of the low-field design.

- A Design Study for a 100 TeV cm pp collider built in the Fermilab region using either low or high field magnets will also be done on a somewhat longer time scale. An outline for this Design Study exists, responsibility for chapters and sub-chapters is being assigned and work is getting done.

- Prototype work will lead in a few years to a technical design.

- The High Field approach has a longer time scale. The key is the magnet. A goal is to have an accelerator usable magnet in 5 years

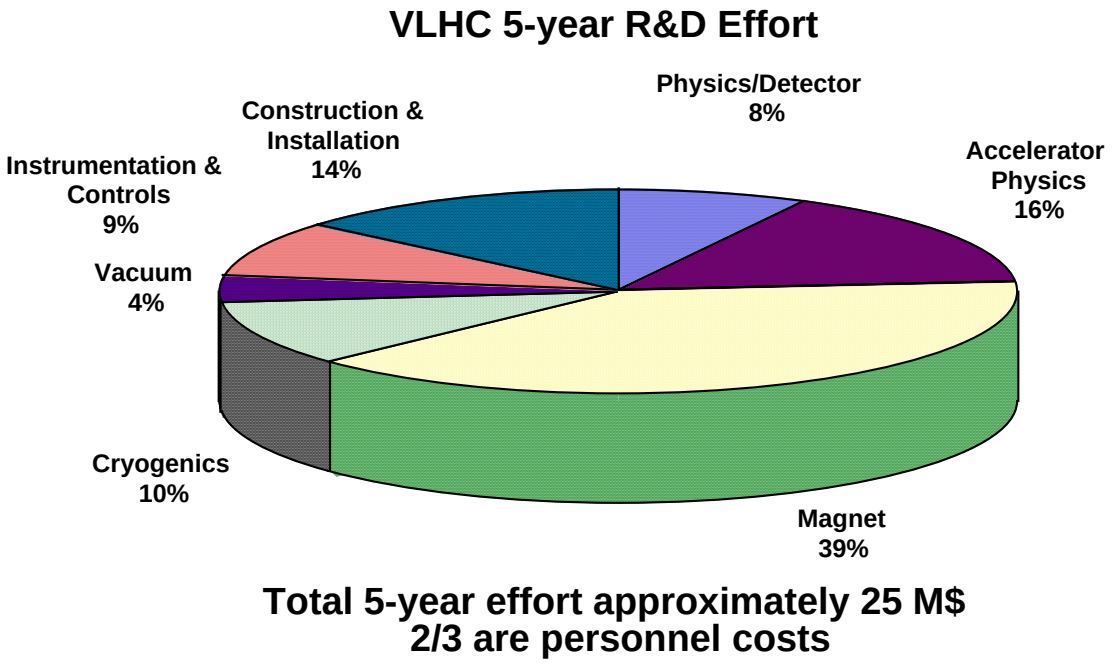
The proposed R&D plan is divided into 7 areas, each with a set of goals. For each a rough estimate of the necessary personnel, materials and supplies can be made. In the tables that follow the personnel costs are based on the following SWF multipliers:

physicist	$72,800
engineer	$79,900
designer/drafter	$60,450
technician	$46,100
administrative	$33,500

To the SWF totals 10% is added for support: computers, office supplies, travel etc. Escalation is not included.

5-year totals by system			
	M&S	personnel	total
Physics/Detector	$220	$1,725	$1,945
Accelerator Physics	$400	$3,462	$3,862
Magnet	$5,800	$3,967	$9,767
Cryogenics	$825	$1,713	$2,538
Vacuum	$350	$735	$1,085
Instrumentation & Controls	$525	$1,686	$2,211
Construction & Installation	$690	$2,700	$3,390
Total	**$8,810**	**$15,988**	**$24,798**

This 5-year effort totals approximately $25M of which 2/3 are personnel costs.



This vigorous R&D program will develop the physics case for the VLHC including preliminary detector parameters, work on accelerator dynamics and find limits imposed by and solutions to instabilities, produce preliminary parameters, conduct R&D on magnets including possible the use of the new emerging high-temperature superconductors. Furthermore we will work with industry on tunneling and robotics. Partnerships with the private sector will be one of the components of our plans to build public support for the VLHC.

Physics and Detector Team

- Hold an annual Spring VLHC Physics/Detector Workshop
- beginning in FY 98 a part-time physicist will work on the detector/machine interface
- FY 00 - 01 begin detector R&D

		FY 98	FY 99	FY 00	FY 01	FY 02	5 yr tot
People required (FTE)							
	physicist	0.5	0.5	1	4	8	
	engineer		0.5	0.5	1	2	
	designer/drafter			0.5	0.5	0.5	
	technician			1	1	1	
	adminstrative						
TOTAL		**0.5**	**1**	**3**	**6.5**	**11.5**	
K$:							
TOTAL M&S		$10	$10	$20	$60	$120	$220
TOTAL SWF		$36	$76	$189	$447	$819	$1,568
add 10 % to SWF		$4	$8	$19	$45	$82	$157
TOTAL		$50	$94	$228	$552	$1,020	$1,945

Accelerator Physics Team

- Has primary responsibility for the Design Study -- goal is distribution by Dec. 1998
- In Spring 1998 hold a workshop on VLHC Accelerator Physics
- During FY 98-99 mostly computational work
- $\geq$ FY 00 Accelerator experiments can begin
- Development of lattice parameters for all machines
    - Low-field 3 TeV
    - Medium (high) field 3 TeV
    - Low-field 50 TeV
    - High field 50 TeV
- Theoretical and experimental investigation of the Resistive Wall Instability
- investigate feasibility of optical stochastic cooling

		FY 98	FY 99	FY 00	FY 01	FY 02	5 yr tot
People required (FTE)							
	physicist	3	4	4	6	8	
	engineer			3	4	4	
	designer/d	0.5	0.5	0.5	0.5	0.5	
	technician			1	2	2	
	adminstrative				1	1	
TOTAL		**3.5**	**4.5**	**8.5**	**13.5**	**15.5**	
K$:							
TOTAL M&S		$50	$50	$75	$100	$125	$400
TOTAL SWF		$249	$321	$607	$912	$1,058	$3,148
add 10 % to SWF		$25	$32	$61	$91	$106	$315
TOTAL		$323	$404	$743	$1,104	$1,289	$3,862

Low-field Magnet Team

- Iron design including crenelations
- Transmission line conductor R&D
- Advanced iron fabrication techniques

- Power Supply, Quench protection, and conductor design
- FY 98 - 99 materials research (with industry); joints
- FY 00 100 meter prototype
- FY 00 100 kA power supply and current leads
- FY 02 low-field VLHC systems test
- prototypes for beam lines (continue perm magnet program)
- correction magnet prototypes
- Alternate low-field magnet, E-magnet

High-field Magnet Team

- FY 98 materials investigations
- FY 99 physics and engineering calculations
- FY 00 initial prototype effort begins
- FY 02 first high field magnet

		FY 98	FY 99	FY 00	FY 01	FY 02	5 yr tot
People required (FTE)							
	physicist	1.5	3	3	3	5	
	engineer	0.5	1.5	2.5	4	5	
	designer/d	0.25	2	3	4	4	
	technician	0.25	1	2	3	4	
	adminstrat	0.25	0.5	1	1	1	
TOTAL		**2.75**	**8**	**11.5**	**15**	**19**	
K$:							
TOTAL M&S		$300	$500	$1,000	$1,500	$2,500	$5,800
TOTAL SWF		$184	$522	$725	$952	$1,223	$3,606
add 10 % to SWF		$18	$52	$73	$95	$122	$361
TOTAL		$503	$1,074	$1,798	$2,547	$3,846	$9,767

Cryogenics Team:

- heat Leak measurements
- evaluation of new-technology superinsulation
- low heat leak spider development,
- cold-pipe material evaluation and prototype
- cryogen distribution line design
- conceptual design and cost optimization of cryo system
- this team will also be concerned with powering the magnets and quench protection

		FY 98	FY 99	FY 00	FY 01	FY 02	5 yr tot
People required (FTE)							
	physicist	0.25	0.5	1	1	1	
	engineer	0.25	0.5	1	2	3	
	designer/drafter		1	1	1	1	
	technician	1	1	2	2	2	
	adminstrative		1	1	1	1	
TOTAL		**1.5**	**4**	**6**	**7**	**8**	
K$:							
TOTAL M&S		$50	$100	$200	$200	$275	$825
TOTAL SWF		$84	$216	$339	$419	$499	$1,557
add 10 % to SWF		$8	$22	$34	$42	$50	$156
TOTAL		$143	$338	$573	$661	$824	$2,538

Vacuum Team

- It is expected that some of this work will be carried out KEK under the Japan-US collaboration
- Engineering analysis of thermal effects
- Determine if NEG material heated from inside or outside
- build vacuum system to measure system parameters
- determine pump spacing and system response times
- learn how to handle long length objects
- build 150 m test setup (most equipment available)
- perform roughing calculations and tests
- purchase/evaluate aluminum, non-air operated gate valves
- welding machines to join ends

		FY 98	FY 99	FY 00	FY 01	FY 02	5 yr tot
People required (FTE)							
	physicist	0.25	0.5	0.5	1	1	
	engineer	0.25	0.25	0.25	0.5	1	
	designer/drafter		0.25	0.25	0.5	0.5	
	technician	0	0.5	1	1	1	
	adminstrative						
TOTAL		**0.5**	**1.5**	**2**	**3**	**3.5**	
K$:							
TOTAL M&S		$40	$60	$75	$75	$100	$350
TOTAL SWF		$38	$95	$118	$189	$229	$668
add 10 % to SWF		$4	$9	$12	$19	$23	$67
TOTAL		$82	$164	$204	$283	$352	$1,085

Instrumentation and Controls Team

- "Standard" devices: BLM's, BPM's
- Special devices: construct one/year -- test on Tevatron
    - electron beam transverse emittance measurement

    - synchrotron light device
    - multiple electrode pickup

- controls: prototype a "LUMP"; this includes:
    - two split-ring BPM's with log amps, sample & hold
    - extruded-aluminum or heliax loss monitors, with power
    - 10 MHz digitizers for BPM signals
    - local controls computer
    - network connection
    - correction element power supplies
    - vacuum controls and readback
    - clock system-- event clock and beam sync clock
- packaging, heat loads, demonstrate connectivity
- research on radiation hardness of single-mode fibers

		FY 98	FY 99	FY 00	FY 01	FY 02	5 yr tot
People required (FTE)							
	physicist	0.5	1	3	3	4	
	engineer	0.25	0.25	1	1	2	
	designer/drafter		0.25	0.5	0.5	0.5	
	technician			1	2	2	
	adminstrative						
TOTAL		**0.75**	**1.5**	**5.5**	**6.5**	**8.5**	
K$:							
TOTAL M&S		$50	$50	$100	$150	$175	$525
TOTAL SWF		$56	$108	$375	$421	$573	$1,533
add 10 % to SWF		$6	$11	$37	$42	$57	$153
TOTAL		$112	$169	$512	$613	$806	$2,211

Construction and Installation Team

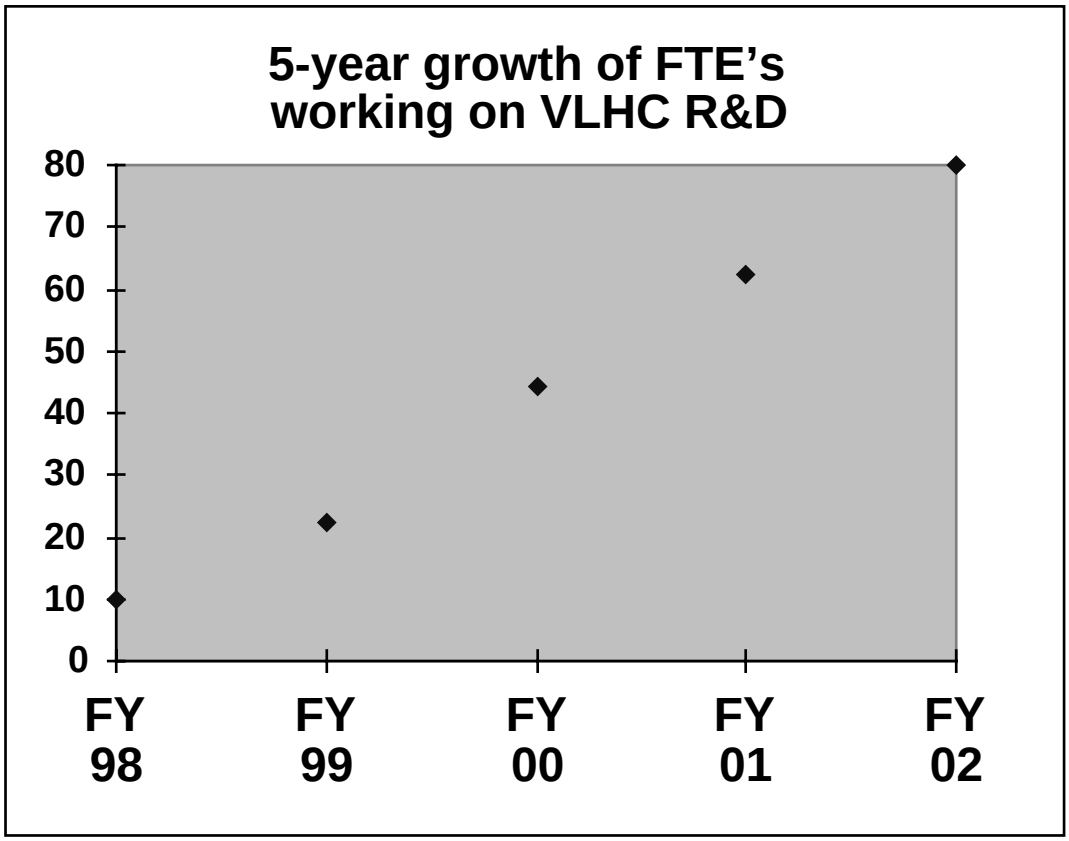
- Develop cost models to understand effect of varying parameters -- this work has already begun with two independent efforts; results will be available before the end of CY 97.
- carry out (or observe) Tunnel Lining experiments
- Utilities: tunnel environment, beam loss and radiation issues
- power distribution to "lumps"
- work on installation issues: layout (more than one machine), invert (tunnel floor), stands
- build full-scale tunnel mockups
- conduct vibrations studies and investigate other causes of emittance growth; this work has already begun -- some of it will be carried out in TARP tunnels to understand the change of the noise spectrum with depth
- begin cutter optimization in FY 00 (subcontract to the Colorado School of Mines)
- FY 00 design of installation vehicles, alignment robot followed by prototype work

		FY 98	FY 99	FY 00	FY 01	FY 02	5 yr tot
People required (FTE)							
	physicist	0.25	0.25	2	4	5	
	engineer	0.25	0.5	3	4	6	
	designer/drafter		0.25	1	1	1	
	technician		1	2	2	2	
	adminstrative						
TOTAL		**0.5**	**2**	**8**	**11**	**14**	
K$:							
TOTAL M&S		$75	$90	$150	$175	$200	$690
TOTAL SWF		$38	$119	$538	$763	$996	$2,455
add 10 % to SWF		$4	$12	$54	$76	$100	$245
TOTAL		$117	$221	$742	$1,015	$1,296	$3,390

Ramp up of the effort

An organization now exists that is focusing and coordinating the efforts. Our R&D goals are aggressive and depend on sufficient resources becoming available. Clearly, Fermilab's rich future physics program must take priority, but gradually resources will become available. e.g. upon completion of accelerator physics calculations for the Main Injector/Recycler -- accelerator physicists will be freed up to work on VLHC. Completion of magnet building (retrofitting main ring parts) for the Main Injector may free up a few magnet designers and specialists. Some of these people are already working part-time on the VLHC magnets. With completion of the 1997-1998 long shutdown some mechanical and electrical engineers will be available.

		FY 98	FY 99	FY 00	FY 01	FY 02	5 yr tot
People required (FTE)							
physicists		6.25	9.75	14.5	22	32	84.5
engineers		1.5	3.5	11.25	16.5	23	55.75
designers/drafters		0.75	4.25	6.75	8	8	27.75
technicians		1.25	3.5	10	13	14	41.75
adminstrative		0.25	1.5	2	3	3	9.75
TOTAL		**10**	**22.5**	**44.5**	**62.5**	**80**	**219.5**
K$:							
TOTAL M&S		$575	$860	$1,620	$2,260	$3,495	$8,810
TOTAL SWF		$686	$1,458	$2,891	$4,103	$5,397	$14,535
add 10 % to SWF		$69	$146	$289	$410	$540	$1,453
TOTAL		$1,330	$2,464	$4,800	$6,774	$9,431	$24,798


5-year growth of FTE's working on VLHC R&D
80
70
60
50
40
30
20
10
0
FY 98
FY 99
FY 00
FY 01
FY 02